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(54) **Rotary drill bit for deep-well drilling**

(57) A rotary drill bit for deep-well drilling, consisting of a body member 1, a threaded pin 2, for connection to a drilling string or the like rotary drive and a head which is provided with cutting elements which extend from the base region of the head into its central region and are combined, in groups in the form of rows or strips, as cutters 3, 4 projecting beyond the outer periphery of the bit, said cutting elements comprising both cutting elements 6 which have only one plane cutting face and cutting elements 5 with a divided cutting face the component faces of the divided cutting face being at a mutual angle to one another of less than 180°.

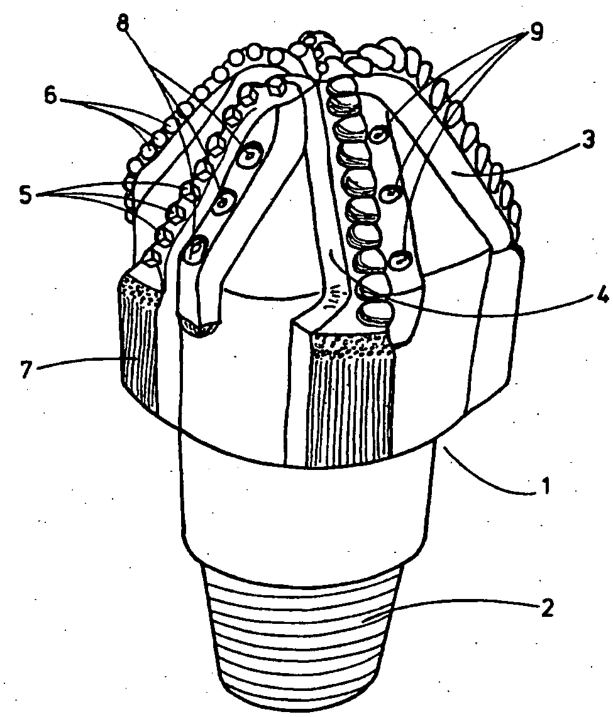

Fig. 1

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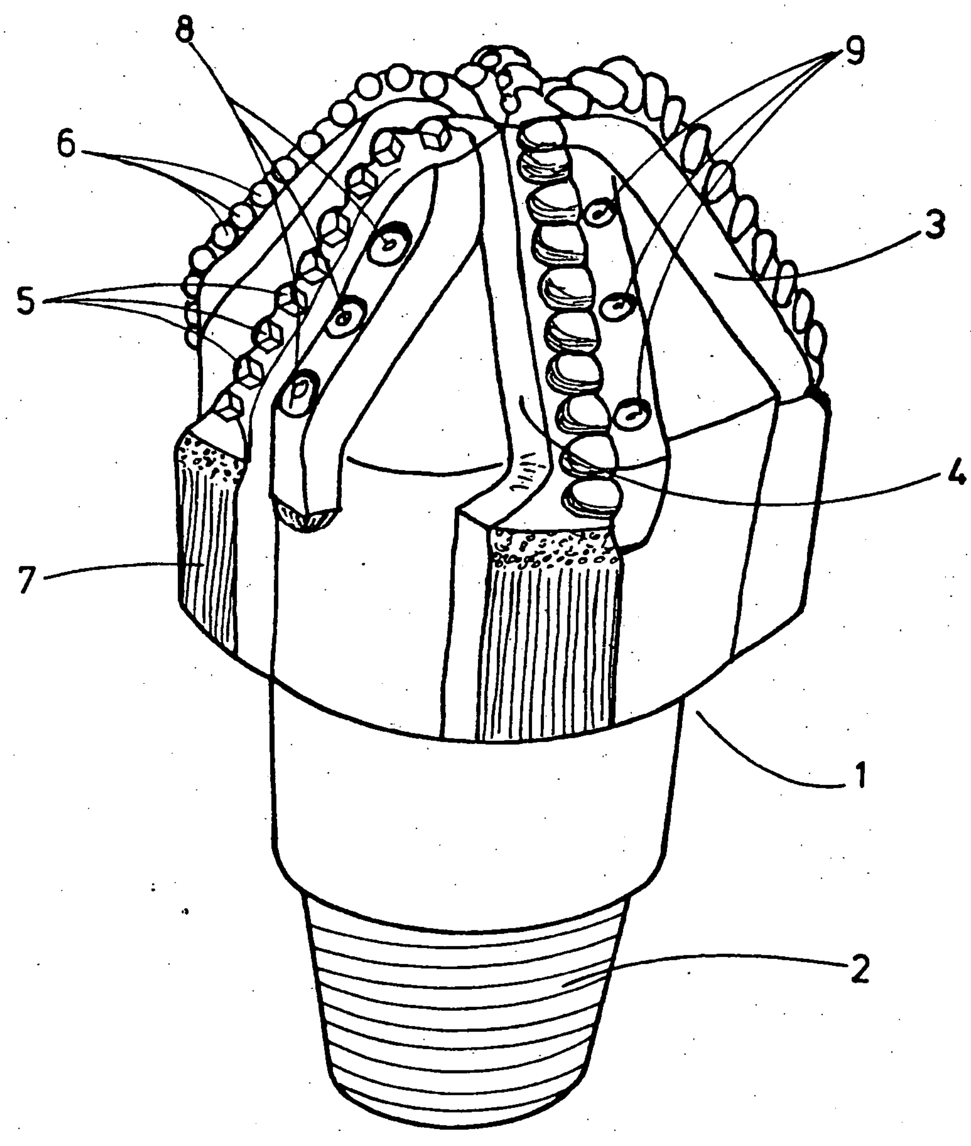

Fig. 1

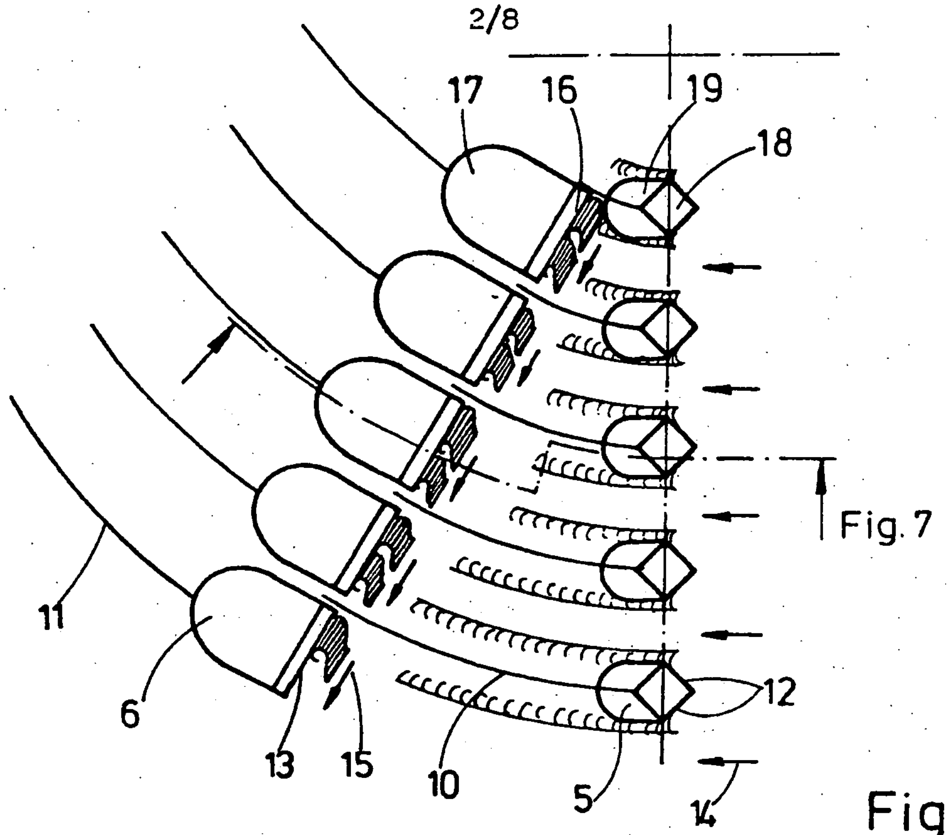

Fig. 2

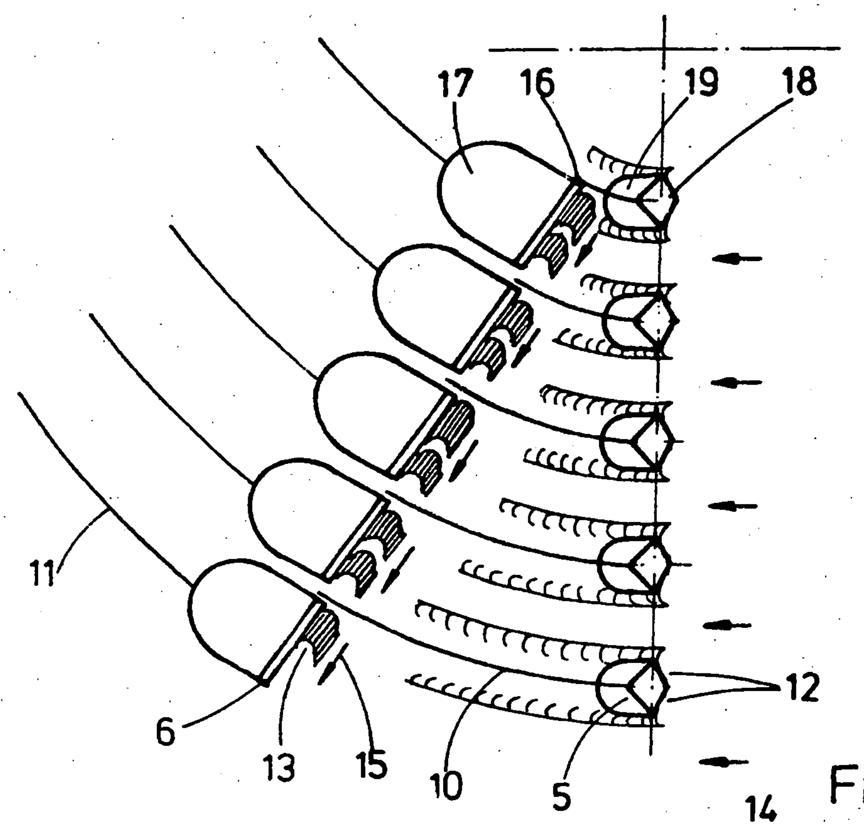

Fig. 3

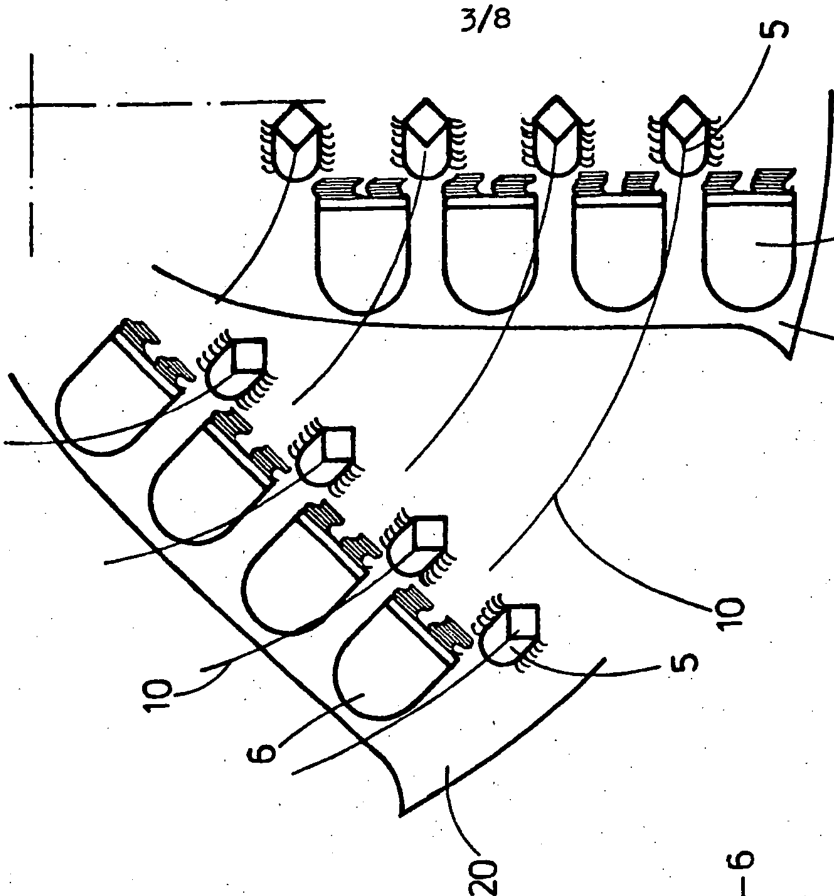

Fig. 4b

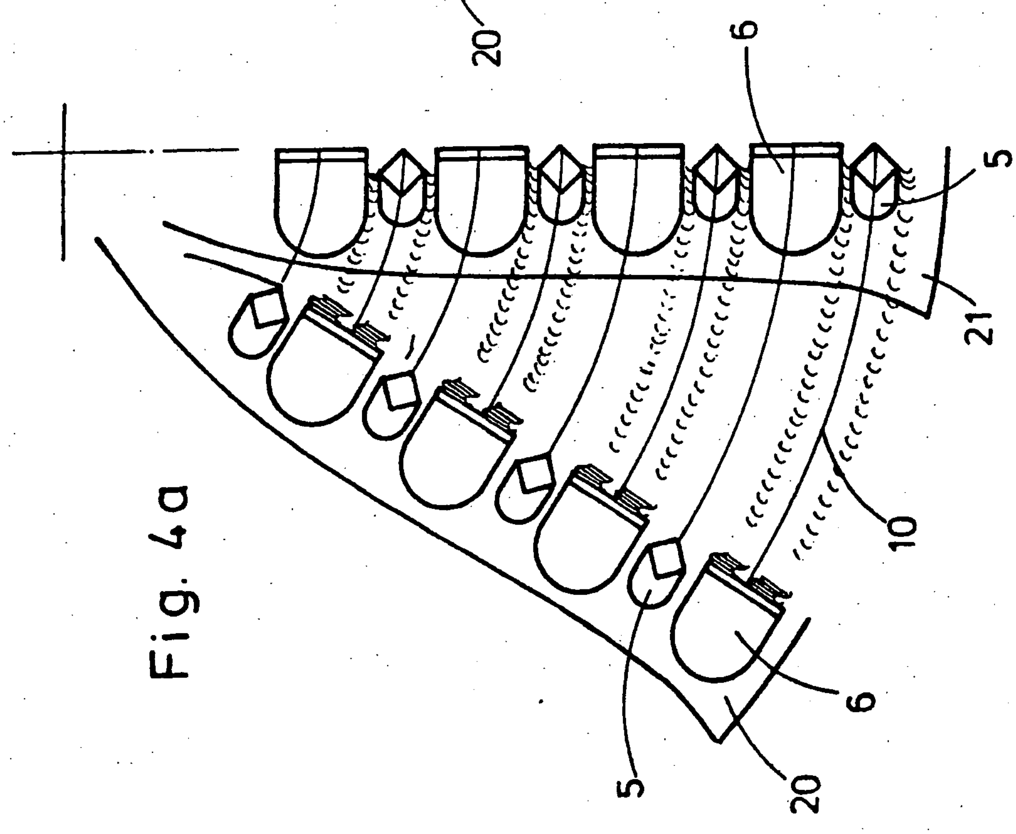

Fig. 4a

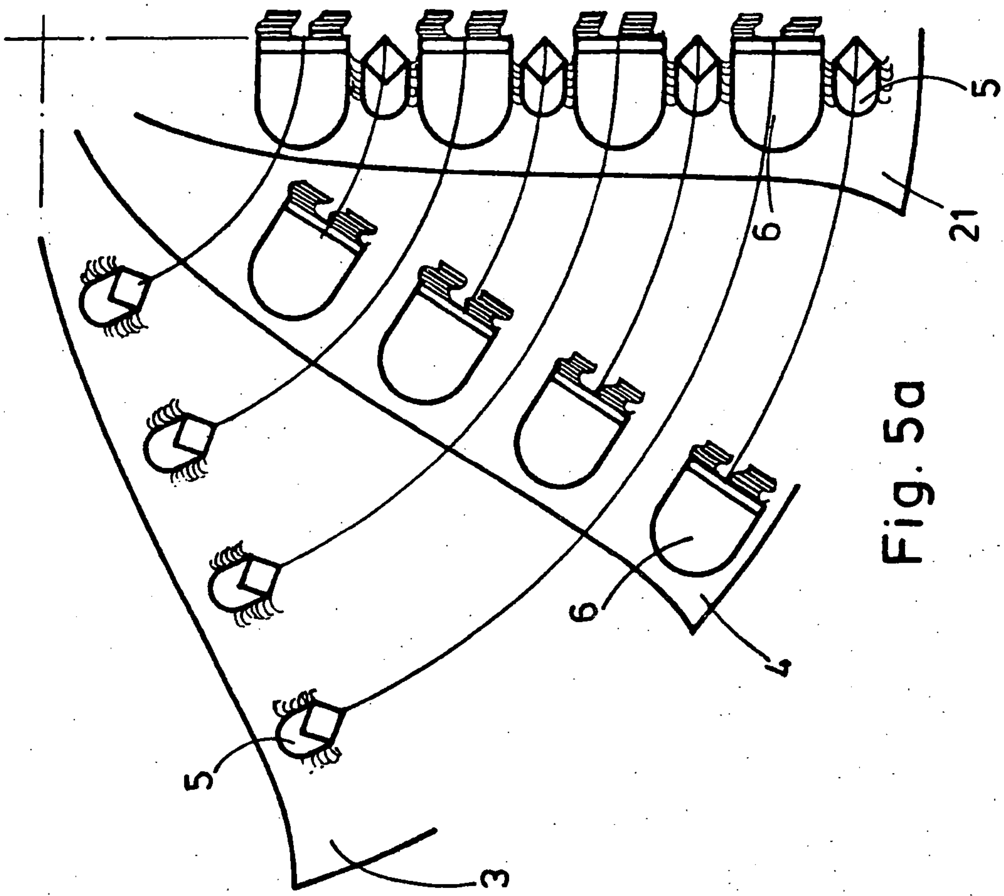

Fig. 5a

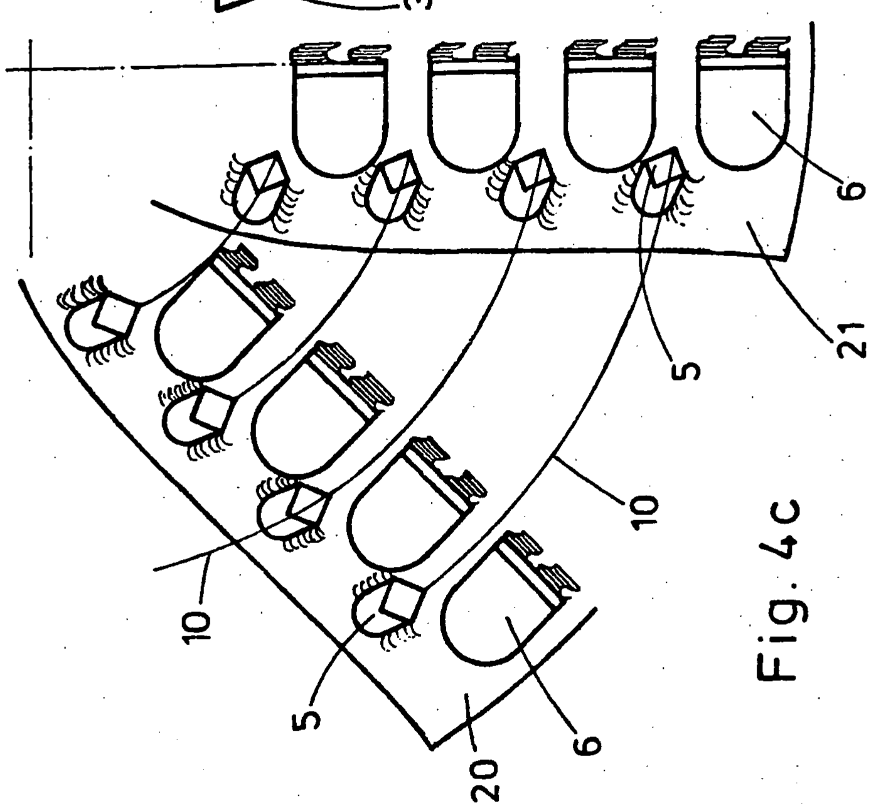

Fig. 4c

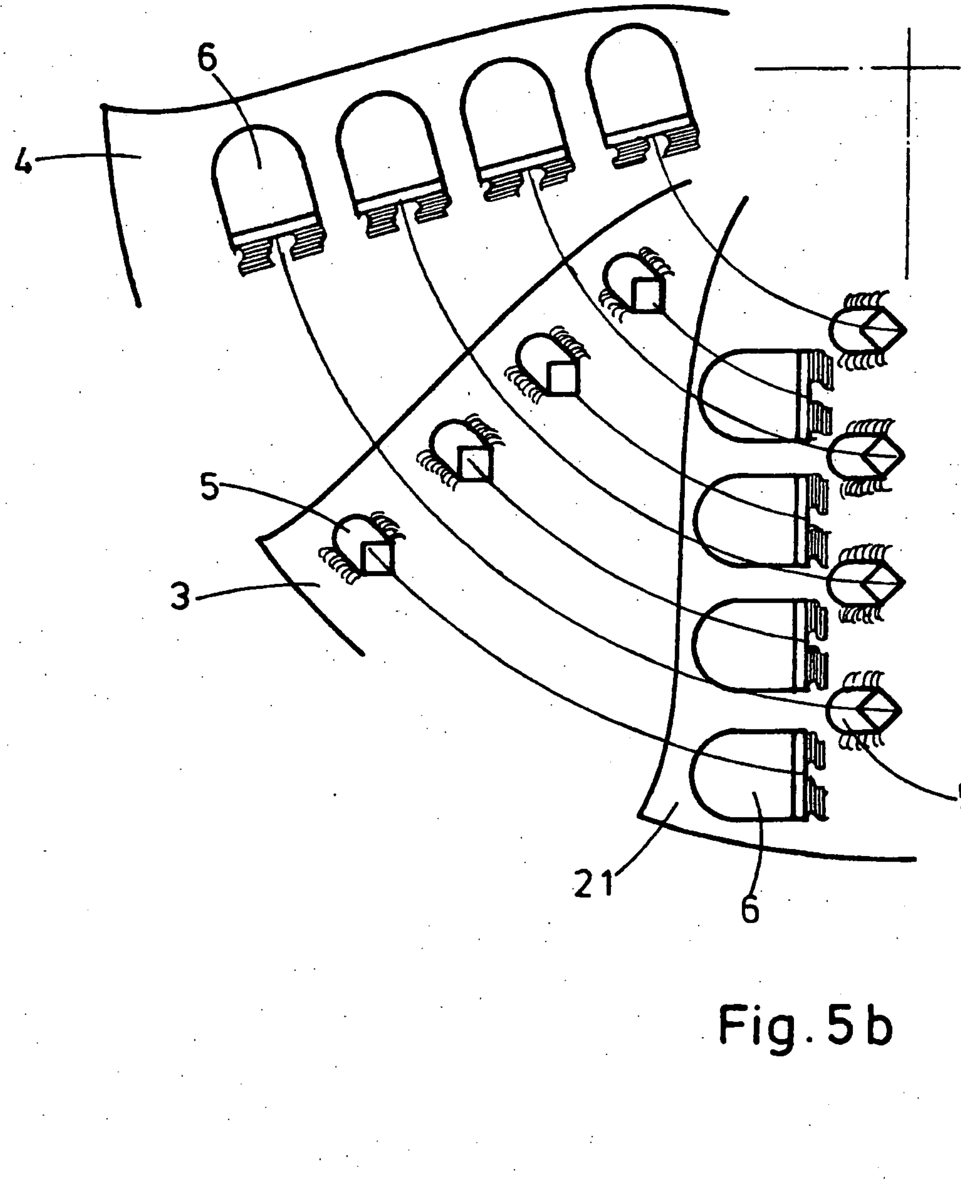

Fig. 5b

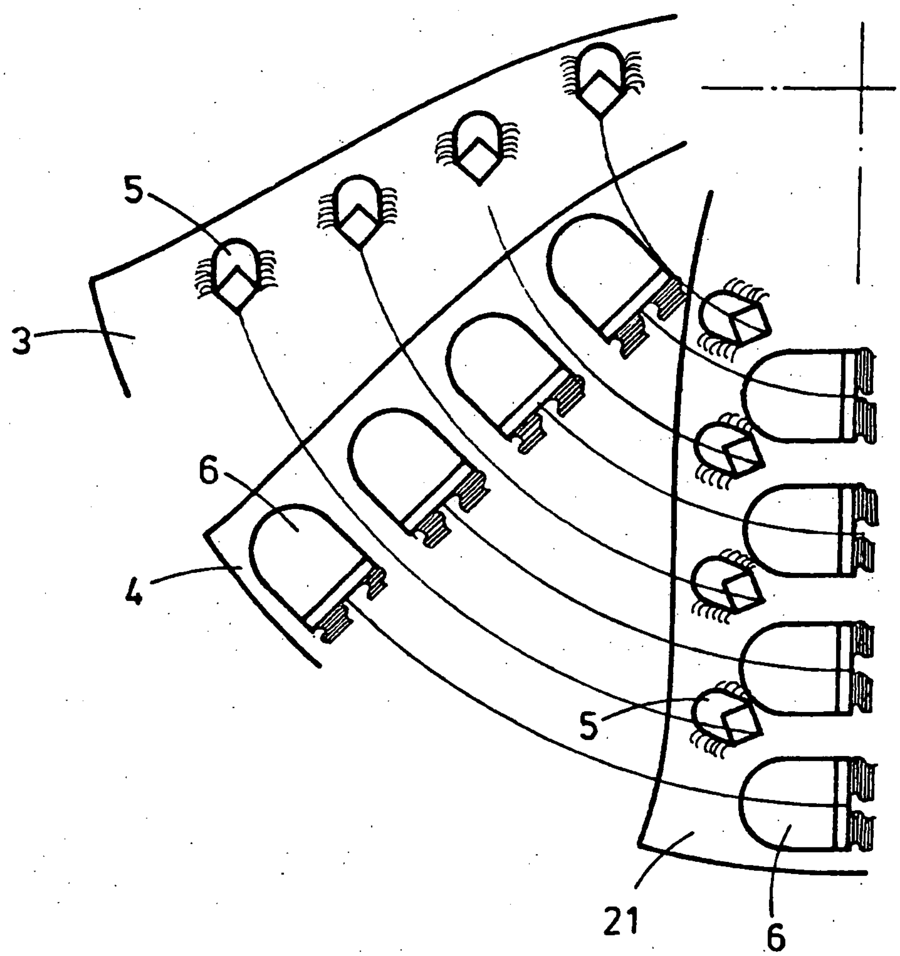

Fig. 5c

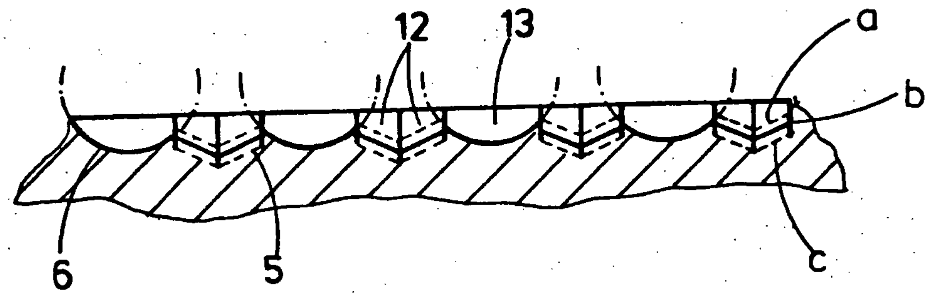

Fig. 6

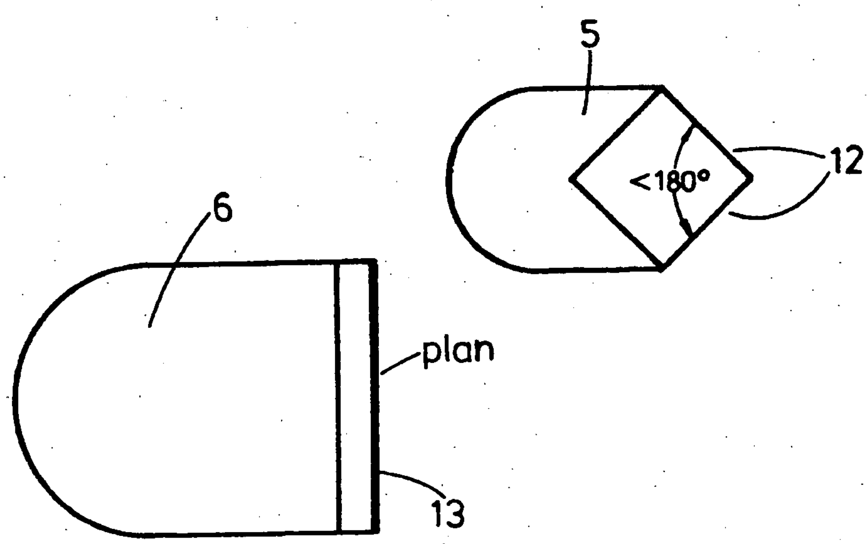

Fig. 8

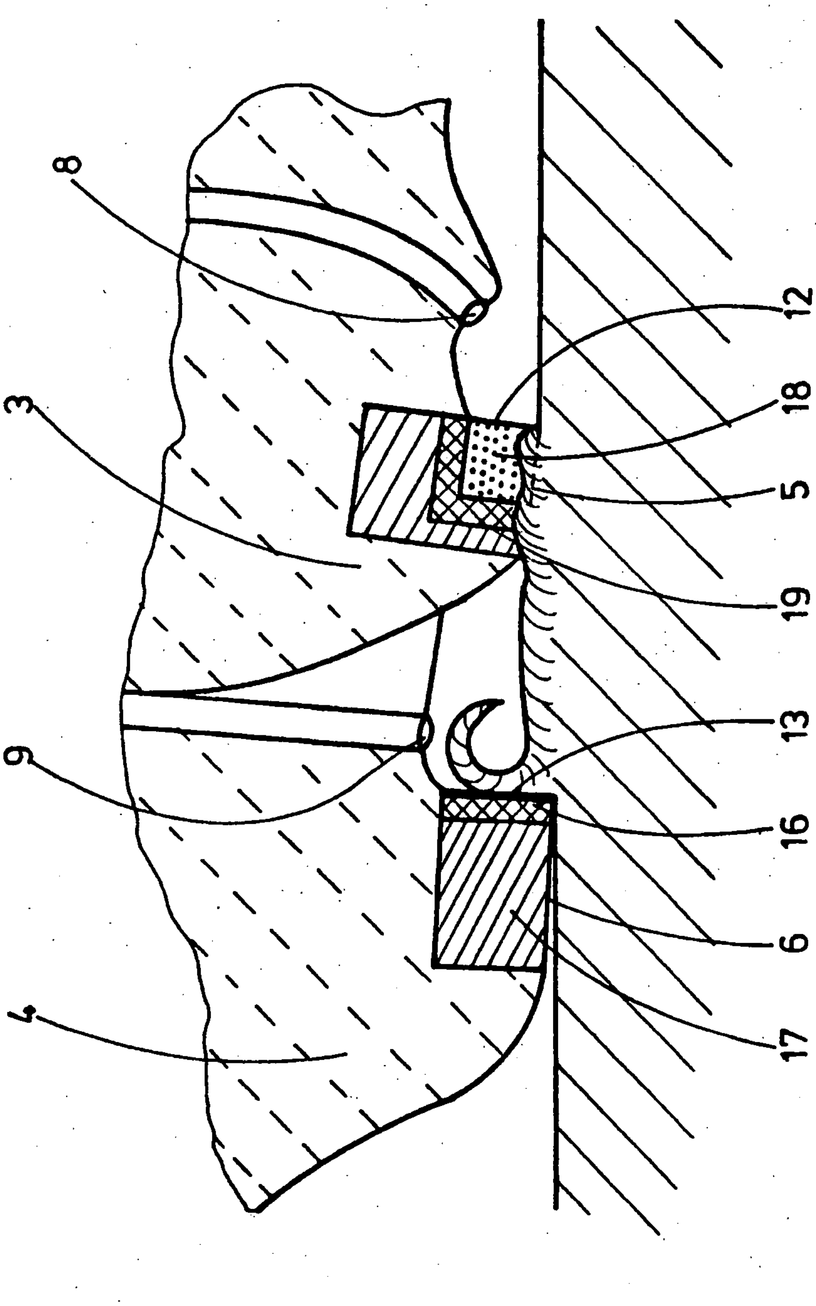

Fig. 7

SPECIFICATION

Rotary drill bit for deep-well drilling

The invention relates to a rotary drill bit for deep-well drilling.

During the sinking of deep wells in the surface of the earth, such drill bits impinge on layers of rock of different hardness and partially plastic formation and are therefore exposed to changing drilling conditions. It has been found that known rotary drill bits with cutting edges which comprise sintered diamond cutting elements which are circular or partially circular in plan view, do not achieve the optimum drilling progress under all drilling conditions. Whereas such drill bits produce satisfactory results with hard sandy layers, with soft plastic rock their cutting elements tend to stick at the cutting face through accumulation of the rock removed and then slide over the layer of rock without chip formation. Rapid wear of the cutting edges then occurs so that the bit becomes too blunt for rock drilling. In order to achieve a chip formation nevertheless, the drill bit would have to be driven carefully with a very great axial thrust force which would greatly increase the wear and the necessary torque.

On the other hand, a rotary drill bit which is provided with wedge shaped cutting elements is particularly suitable for soft formations. As a result of the geometry of the cutting edges, particularly as a result of cutting faces extending at an acute angle to the cutting direction, a plough effect is achieved which permits better chip formation of the rock removed with less axial thrust force and less torque. The relatively small effective area of the cutting elements permits the removal of only a small amount of material, however, so that the drilling progress of such bits is considerably less in comparison with the drilling progress of a bit equipped with circular or partially circular cutting elements. It is an object of the present invention to provide an improved rotary drill bit so that a greater drilling progress is achieved over the widest possible hardness and plasticity spectrum of the rock formation paying special consideration to soft rock.

The present invention is a rotary drill bit for deep-well drilling, consisting of a body member, a threaded pin for connection to a drilling string or the like rotary drive and a head which is provided with cutting elements which extend from the base region of the head into its central region and are combined, in groups in the form of rows or strips, as cutters projecting beyond the outer periphery of the bit, said cutting elements comprising both cutting elements which have only one plane cutting face and cutting elements with a divided cutting face, the component faces of the divided cutting face being at a mutual angle to one another of less than 180°.

The cutting elements with a plane cutting face serve for cutting paring and removal of the rock during the drilling operation. With hard sandy rock, these cutting elements master the greatest cutting work. With softer rock there is a functional cooperation between the said cutting elements with a plane cutting face and the cutting elements with a divided cutting face which are disposed offset with regard to the lines of intersection according to an advantageous form of embodiment. Because of their greater pressure per unit area, the cutting elements with a divided cutting face can penetrate into the formation and engrave a furrow there, leaving behind lateral mounds produced by chip formation. This effect occurs already with cutting faces the component faces of which are at an angle of somewhat less than 180°. The effect is improved as the angle between the cutting faces becomes smaller. As a result of the disturbance in its structure caused by the penetration into the formation, a uniform sliding of the rock structure under the cutting edge of the following cutting element is prevented and it is possible for this to pare off the torn plane of the rock, forming chips. In order to cause the chip formation, less axial thrust force is necessary than would be the case with bits which were equipped exclusively with cutting elements which only had a plane cutting face. The wear and the necessary torque are likewise less. A bit with a combination of the said cutting elements renders possible, particularly with soft rock, a considerably greater drilling progress than with the exclusive use of a bit equipped with only one alternative of the two kinds of cutting element.

In order to reinforce the cutting work and to cool the cutting elements, groups of nozzles are disposed in front of the cutting elements, the flushing outlet direction of which nozzles is such that the effect of the particular cutting elements is reinforced. Since the cutting elements with a divided cutting face are only intended to tear up the formation, the drill chips displaced as with a snow-plough, slide laterally through between two adjacent cutting elements. This tangential direction is also impressed on the flushing stream of the flushing supplied by the associated nozzles so that the sliding of the chips along the component faces, at an angle to one another, of the cutting elements with a divided cutting face is facilitated and clogging of the gaps between the cutting elements is prevented. The nozzles disposed in front of the cutting elements with a plane cutting face impose a radial component on the flushing stream so that the chips running off along the cutting faces of these cutting elements are forced away to the outside, are cut off and the drillings can be removed. The cutting face of these cutting elements can also be set at an angle to the cutting direction in order to achieve an outwardly directed plough effect.

Whereas the cutting elements with a plane cutting face preferably consist of a thin layer of polycrystalline sintered diamond are each secured to a uniformly supported supporting member, the cutting elements with a divided cutting face may comprise natural diamond or ploycrystalline sintered diamond cut up by a severing process as a material. The cutting elements are bound in special holders and are securely held there.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 shows a perspective view of a rotary drill bit according to the present invention which is

equipped with a combination of plane and wedge shaped cutting elements;

Figure 2 shows a projection of the sectional plane of a group of wedge shaped cutting elements with a divided cutting face and a group of cutting elements with a plane cutting face;

Figure 3 shows a modification of the configuration and embodiment illustrated in Figure 2;

Figures 4 a, b, c and Figures 5a, b, c show further possible arrangements of the cutting elements.

In Figure 1 a rotary drill bit is illustrated which comprises a body member 1, a threaded pin 2 for a connection to a drilling string and a head with cutters 3, 4. The cutters 3 and 4 comprise cutting elements 5 and 6 projecting from strip-shaped elevations extending radially from the base region of the bit to the centre. In the base region, this elevation is continued over a short axial distance and is equipped with a hard covering 7 which is impregnated of superficially equipped with abrasion-resistant material. In the valleys between the elevations, nozzles 8, 9 are disposed in front of the cutting elements in each case, which nozzles are intended to defelct the flushing stream and are in communication, at the inlet side, with an internal bore. The nozzles are fewer in number than the cutting elements but the outlet cone of the flushing stream is so designed that all the cutting elements are adequately supplied with flushing. The nozzles 8 associated with the cutting elements 5 have a smaller cross-section than the nozzles 9 associated with the cutting elements 6. The nozzles 8 are so aligned that they direct the flushing streams tangentially to the drill bit towards the cutting elements 5. The nozzles 9, on the other hand, direct their flushing streams in a radial direction towards the base region of the bit as a result of their alignment. The cutting elements 6 consist of small thin plates of polycrystalline sintered diamond which are circular in plan view and are secured to hard-metal supporting members. These, in turn, are embedded in a matrix-binder composition. The plane cutting faces of the cutting elements 5 are at right angles to the cutting direction. it is also possible, however, to dispose them at an obtuse angle so that the flow of chips to the base region of the bit is reinforced by a slight plough effect. The cutting elements 5 consist of natural diamonds (cubes) and are embedded in hard-metal holders which in turn again rest in matrix-binder composition. The cutting elements 5 may, however, also be formed by severed sintered diamond members. In the cutting direction, each cutting element is bounded by two faces arranged as a wedge which act as cutting faces during the cutting operation and in the radial direction it is bounded by apointed face which acts as a flank. The three abutting edges of the said faces act as cutting edges. The point formed by the common connecting point of the cutting edges and the front cutting edge develop such a high pressure per unit area on the formation that penetration of the cutting elements into the layer of rock is ensured. Between two adjacent cutting elements 5 there is an adequate gap which allows the torn up chips to pass through.

The cooperation of the said cutting elements will now be considered with reference to Figure 2. The Figure is restricted to a cooperating pair of cutters consisting of a cutter 3 carrying prismatic cutting elements 5 with cutting faces arranged in a wedge to form a divided cutting face and the cutter 4 which in this particular case carries cutting elements 6 with a plane cutting face and a circular cutting edge contour. The reference numerals 18 and 19 distinguish the cutter elements with the divided cutting faces and the supporting members therefore while the reference numerals 16 and 17 distinguish a circular cutting element with a plane face and its holder. The cutting faces of the prismatic cutting element are designated by 12, while the cutting face of the circular cutting element is designated by 13. The lines of intersection 10 and 11, which distinguish the position of the deepest penetration of the cutting elements into the formation, show that the cutting elements are staggered in arrangement. The flushing flow impressed by the nozzles, not shown, is represented by arrows 14 and 15. The flushing stream runs first counter to the direction of rotation of the bit through the gaps in the prismatic cutting elements 5 and changes its direction to the outside along the cutting elements 6 shape. The chip pared off is indicated in the drawing along the path described by the cutting elements. While the formation is only broken up by the prismatic cutting elements, the further paring off is effected by the circular cutting elements.

It is clear how the cutting elements supplements one another in the cutting work and how the flushing contributes to guiding the pared off drillings along the cutting faces of the cutting elements and conveying them away to the outside.

As a modification of the embodiment illustrated in Figure 2, Figure 3 shows cutting elements 6 with a plane cutting face 13 set at an angle and cutting elements 5 with a divided cutting face 12, the component faces of which are at an angle of less than 180° to one another. For the setting angle of the cutting elements 6, a range between 0° and 40° has proved advantageous.

Cooperation between the two kinds of cutting element results with other possible arrangements than those illustrated in Figures 1 to 3. Then, however, the path of the flushing liquid as described by the selection and alignment of suitable nozzles is no longer simply applicable.

Figures 4a, b, c show a combined arrangement of the various cutting elements 5, 6 on cuts 20, 21.

With the arrangement of the cutting elements in Figures 4a and c, the formation is torn up by the cutting elements 5 with a divided cutting face 12 on the cutter 21 and pared off by the cutting elements 6 with a plane cutting face 13, disposed on the following cutter 20.

With the version shown in Figure 4b, the tearing up and paring off of the formation is effected by the same cutter because this already comprises the two kinds of cutting element arranged according to the working sequence, namely cutting elements 6 behind cutting elements 5.

Figures 5a, b, c show arrangements which consist of a combination of the cutters 20 or 21, as illustrated in Figures 4a, b, c, with the cutters 3 and 4 of Figure

2. The interplay of the cutting elements 5 and 6 with a divided cutting face 12 and with a plane cutting face 13 is thus also possible when the cutting elements are disposed partly together, partly separately on the cutters.

Figure 6 shows a section extending radially through the drilled formation with a view of the cutting faces of the cutting elements, the cutting elements 5 with a divided cutting face 12 being disposed in front of the cutting elements 6 with a plane cutting face 13. The spacing between the cooperating cutting elements 5, 6 can be selected so great that the cutting regions adjoin one another and the torn up chip projects into the cutting region of the following cutting element. A more reliable cutting action is achieved, however, if the cutting regions partially overlap one another.

The cutting depth of the cutting elements 5 with a divided cutting face can also be selected to be different as compared with the cutting depth of the cutting elements 6 with a plane cutting face 13, to optimize the drilling progress of the bit for a specific plasticity of the formation being drilled. The positions a, b, c in Figure 6 show different cutting depths.

Figure 7 shows a longitudinal section, extending substantially tangentially, through a rotary drill bit working in the formation. The sectional plane illustrated extends along the chain line illustrated in Figure 2. The construction of the cutters, cutting elements and nozzles already discussed in connection with the description of Figures 1 and 2 is here illustrated again. Likewise the cooperation of the cutting elements, as mentioned in Figure 2, can be seen from a perspective at the side in relation to the cutting direction.

Figure 8 serves to correlate the terms "plane cutting face" 13, and "divided cutting face" 12 used in this description and to illustrate the angle between the component faces of the divided cutting face 12, which should be less than 180°.

CLAIMS

1. A rotary drill bit for deep-well drilling, consisting of a body member 1, a threaded pin 2, for connection to a drilling string or the like rotary drive and a head which is provided with cutting elements which extend from the base region of the head into its central region and are combined, in groups in the form of rows or strips, as cutters 3, 4 projecting beyond the outer periphery of the bit, said cutting elements comprising both cutting elements 6 which have only one plane cutting face, and cutting elements 5 with a divided cutting face the component faces of the divided cutting face being at a mutual angle to one another of less than 180°.

2. A rotary drill bit as claimed in Claim 1, in that each cutter comprises cutting elements with a plane cutting face and cutting elements with a divided cutting face.

3. A rotary drill bit as claimed in Claim 2, in which the cutting elements with a plane cutting face and the cutting elements with a divided cutting face are disposed alternately, stepped radially from the base region to the central region, on each cutter.

4. A rotary drill bit as claimed in Claim 3, in which both kinds of cutting elements are disposed side by side.

5. A rotary drill bit as claimed in Claim 3, in which the cutting elements with a divided cutting face are disposed offset arcuately in relation to the cutting elements with a plane cutting face.

6. A rotary drill bit as claimed in Claim 3 or 5, in which the cutting elements with a divided cutting face are disposed in front of the cutting elements with a plane cutting face, seen in the direction of rotation of the bit.

7. A rotary drill bit as claimed in Claim 3 or 5, in which the cutting elements with a divided cutting face are disposed behind the cutting elements with a plane cutting face, seen in the direction of rotation of the bit.

8. A rotary drill bit as claimed in Claim 4 or 6, in which the cutting elements are radially offset with respect to similar cutting elements on adjacent cutters.

9. A rotary drill bit as claimed in Claim 7, in which the cutting elements are disposed at the same radius as similar cutting elements on adjacent cutting edges.

10. A rotary drill bit as claimed in Claim 1, in which alternate cutters comprise cutting elements with a plane cutting face and the intermediate cutters comprise cutting elements with a divided cutting face.

11. A rotary drill bit as claimed in Claim 10, in which cutting elements with a plane cutting face are radially offset with regard to the cutting elements with a divided cutting face.

12. A rotary drill bit as claimed in Claim 1, in which cutters with cutting elements provided with a plane cutting face, cutters with cutting elements provided with a divided cutting face, and cutters with both types of cutting element are present.

13. A rotary drill bit as claimed in Claim 12, in which the cutting elements with a divided cutting face are disposed in front of or behind the cutting elements with a plane cutting face, seen in the direction of rotation of the bit, on the common cutter, and in the case of the cutters which comprise exclusively cutting elements with a divided cutting face or a plane cutting face, the same sequence is found in the direction of rotation with regard to the arrangement of the cutting elements.

14. A rotary drill bit as claimed in Claim 12, in which the cutting elements with a divided cutting face and with a plane cutting face are disposed side by side on the common cutter and the cutters which carry exclusively cutting elements with a plane cutting face or with a divided cutting face are disposed in a selectable but uniform sequence behind the common cutter.

15. A rotary drill bit as claimed in one of the Claims 3 to 10 or 12, 13, in which cutting elements with a plane cutting face are adjacent, with their cutting region, to the cutting region of radially adjacent cutting elements with a divided cutting face or are disposed in front thereof in the direction of rotation, or project into these.

16. A rotary drill bit as claimed in any preceding claim, in which the cutting elements with a plane cutting face have an elliptical or semi-elliptical cut-

ting edge contour.

17. A rotary drill bit as claimed in any of Claims 1 to 15, in which the cutting elements with a plane cutting face have a circular or partially circular cutting edge contour.

18. A rotary drill bit as claimed in any of Claims 1 to 15, in which the cutting elements with a divided cutting face have component faces which are at an acute angle to one another in the cutting direction.

19. A rotary drill bit as claimed in any of Claims 1 to 15, in which the cutting elements with a divided cutting face have prismatic contour.

20. A rotary drill bit as claimed in any preceding claim, in the cutting elements with a divided cutting face are dimesioned for a greater cutting depth than the cutting elements with a plane cutting face (13).

21. A rotary drill bit as claimed in any of Claims 1 to 19, in which the cutting elements with a divided cutting face are designed for a shallower cutting depth than the cutting elements with a plane cutting face.

22. A rotary drill bit as claimed in Claim 17, in which the cutting elements consist of a layer of polycrystalline sintered diamond, which is secured to supporting members.

23. A rotary drill bit as claimed in claim 18 or claim 19, in which the cutting elements are formed from natural diamonds or from prismatic sectors of a polycrystalline sintered body and that the sintered bodies or diamonds in turn are mounted in supporting members.

24. A rotary drill bit as claimed in Claim 10 or 11, in which nozzles for flushing liquid are disposed in front of the cutting edges in the direction of rotation of the bit, which nozzles communicate with a central bore in the interior of the bit, and that outlets of the nozzles associated with the cutting elements with a divided cutting face are so directed and constituted that a substantially tangential component of direction in the counter direction of rotation of the bit is impressed on the flushing jet and the outlets of the nozzles associated with the cutting elements with a plane cutting face are so directed and constituted that a component directed substantially radially outwards is impressed on the flushing jet.

25. A rotary drill bit as claimed in Claim 24, in the nozzle cross-section of the nozzles associated with the cutting elements with a divided cutting face (12) is smaller than that of the nozzles associated with the cutting elements with a plane cutting face.

26. A rotary drill bit substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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